Appendix B

Important Concepts and Elements of an Adequate State Watershed Monitoring and Assessment Program

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August 8, 1997

prepared by

Chris O. Yoder
State of Ohio Environmental Protection Agency
Division of Surface Water
1685 Westbelt Drive
Columbus, Ohio 43228

prepared for

U.S. EPA, Office of Water
(Cooperative Agreement CX 825484-01-0)

and

ASIWPCA Standards and Monitoring Task Force

Important Concepts and Elements of an Adequate State Watershed Monitoring and Assessment Program

I. INTRODUCTION

Watershed-based approaches are gaining widespread acceptance as a conceptual framework from within which water quality management programs should function. However, overall reductions and inequities in State ambient monitoring and assessment programs jeopardize the scientific integrity of watershed-based approaches. This also has had the undesirable effect of failing to properly equip the States and EPA to adequately meet the challenges posed by recently emerging issues such as cumulative effects, nonpoint sources, habitat degradation, and interdisciplinary issues (*e.g.,* TMDLs) in general. Unfortunately, the chronic shortfall in ambient monitoring and assessment resources is not new - the ITFM (1995) reported that of the funding allocated by state and federal agencies to water quality management activities, only 0.2% was devoted to ambient monitoring. As the need for adequate supplies of clean water increases, concerns about public health and the environment escalate, and geographically targeted watershed-based approaches increase, the demands on the water quality monitoring "infrastructure" will likewise increase. These demands cannot be met effectively nor economically without fundamentally changing our attitudes towards ambient monitoring (ITFM 1995). An adequate ambient monitoring and assessment framework is needed to ensure not only a good science-based foundation for watershed-based approaches, but water quality management in general. This paper attempts to describe the important elements, processes, and frameworks which need to be included as part of an adequate State monitoring and assessment program and how this should be used to support the overall water quality management process. Furthermore, it is a goal of this effort to highlight the need to revitalize monitoring, assessment, and environmental indicators as an integral part of the overall water quality management process.

Monitoring and assessment information, when based on a sufficiently comprehensive and rigorous system of environmental indicators, is integral to protecting human health, preserving and restoring ecosystem integrity, and sustaining a viable economy. Such a strategy is intended to achieve a better return on public and private investments in environmental protection and natural resources management. In short, more and better monitoring and assessment information is needed to answer the fundamental questions that have been repeatedly asked about the condition of our water resources and shape the strategies needed to deal with both existing and emerging problems within the context of watershed-based management.

The long-term vision is to develop a process for the comprehensive assessment of the waters of each State by producing and implementing a multi-year monitoring and assessment framework at relevant geographic scales to support all water quality management objectives (including risk-based decision making). Some of the key elements of this approach are:

- development and implementation of a statewide monitoring strategy.
- publishing existing monitoring and assessment results from all relevant sources (*e.g.,* Watershed specific reports, State 305[b] reports).
- performance of data storage, retrieval, and management.
- taking appropriate regulatory and management actions based on those results.

These efforts would fall short if a linkage between program management and monitoring and assessment were not made part of the overall water quality management process (Figure 1). This, too, is part of the long range vision for revitalizing the role of water quality monitoring nationwide.

II. GOALS OF AN ADEQUATE STATE MONITORING AND ASSESSMENT PROGRAM

The following is a compilation of the major program goals that should shape the design of an adequate State monitoring and assessment program and thus become the identifiable characteristics. While much of this is patterned after the major monitoring and assessment compendia and program guidance that has recently been developed (ITFM 1995; U.S. EPA 106 Program Guidance), the specifics of implementation lie within the custodial responsibilities of State water quality management programs.

1. The **18 national water indicators** and the goals each measures (U.S. EPA 1995a; see inset p. 3) are employed as the core indicators with additional area and/or resource specific goals and indicators as needed to fulfill the following purposes:

    - conserve and enhance public health.
    - conserve and enhance ecosystems.
    - support uses designated by States/Tribes in Water Quality Standards (WQS).
    - conserve and improve ambient conditions.
    - reduce or prevent loadings and other stressors (*e.g.*, habitat degradation).

Taken together, all of the above should lead to achieving healthy watersheds.

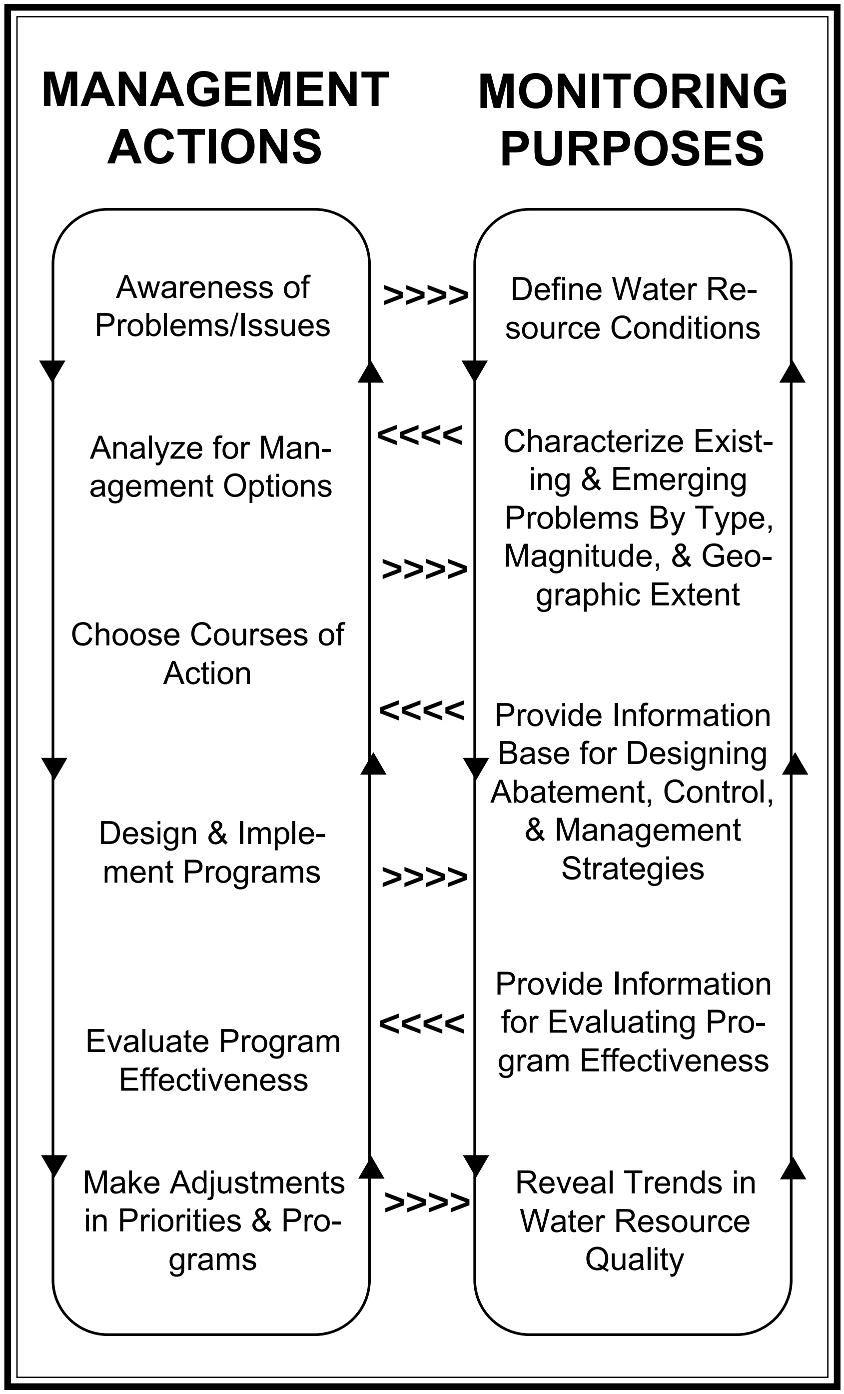

Figure 1. The relationship between management actions and the purposes monitoring and assessment (after ITFM 1995).

2. **Assess all water resource types** within an organized time frame (*e.g.*, rotating basin approach) by employing the following approaches:

The U.S. EPA National Indicators for Water and the Goals Each Supports

Conserve & Enhance Public Health:

1. Population served by drinking water systems in compliance with health-based standards.
2. Population served by drinking water systems at risk from microbial contamination.
3. Population served by drinking water systems exceeding lead action levels.
4. Number of drinking water systems with source water protection.
5. Percentage of waters with fish consumption advisories.
6. Percentage of estuarine and shellfish waters approved for harvest for human consumption.

Conserve & Enhance Ecosystems:

7. Percentage of waters with healthy aquatic communities (*i.e.*, biological integrity).
8. Percentage of imperiled aquatic species.
9. Rate of wetland acreage loss.

Support Designated Uses:

10. Percentage of waters meeting designated uses:
    a. Drinking water supply
    b. Fish and shellfish consumption
    c. Recreational
    d. Aquatic life

Conserve & Improve Ambient Conditions:

11. Population exposed to chemical pollutants in ground water.
12. Trends in surface water pollutants.
13. Concentrations of selected pollutants in shellfish.
14. Trends in estuarine eutrophication.
15. Percentage of waters with chemically contaminated sediments.

Reduce Loadings & Prevent Other Stressors:

16. Point source loadings to surface and ground water.
17. Nonpoint source loadings to surface and ground water.
18. Marine debris.

- achieve virtually 100% coverage through a mix of different spatial schemes, *i.e.*, targeted sites, rotating basin cycles, and/or probabilistic design.
- utilize appropriate and robust techniques for extrapolation and stratification of monitoring and assessment results (*i.e.*, every mile of every stream need not be monitored to achieve the 100% coverage goal).
- maximize interagency and inter-organizational cooperation and collaboration.
- when appropriate, make use of volunteer organization results.

3. Produce a **"better" 305b report:**

- national statistics are currently biased by wide differences between State approaches to monitoring & assessment including indicators usage and calibration - one result is widely divergent state estimates of impaired waters (generally overly optimistic estimates of the full attainment of aquatic life uses).
- assignment of impairment (or lack thereof) to associated causes and sources also reveals the inconsistent usage of indicators and indicator frameworks - *e.g.*, habitat has been under reported by most states (almost one-half of states reported *zero* impaired miles for rivers & streams in 1992).

4. Support the emerging **watershed approaches**:

- reductions in State monitoring & assessment programs jeopardize the science basis for successfully implementing watershed-based approaches which are ostensibly based (in part) on addressing previously overlooked or under-emphasized problems.
- management applications most commonly take place at the watershed level thus monitoring & assessment must be relevant to this level of management and be capable of detecting impairments and characterizing aquatic resources at this scale.

5. **Satisfy basic questions** that are frequently encountered by water quality program managers:
   - what is the condition of surface, ground, estuarine, and coastal waters?
   - how and why are conditions changing over time?
   - what are the associated causes and sources of impairment?
   - are water quality management programs producing the desired results?
   - are state and national water quality goals being attained?

Each of the above can be subdivided into issue specific questions that are commonly encountered by water quality managers (see inset at right).

6. **Integrate the water resource integrity concepts** that have been developed during the past 10-15 years into monitoring and assessment approaches, environmental indicators, and watershed-based programs:

   - the five factors that determine the integrity of water resources (Figure 2; Karr *et al.* 1986) should be used to guide the development of environmental indicators - indicators which both represent or extend to each major factor *and* which reflect the integrity of the water resource as a whole (*e.g.*, composite measures, indices) are needed.
   - follow the stressor, exposure, response paradigm for determining the most appropriate roles for individual indicators - *avoid the inappropriate substitution of stressor and exposure indicators for response indicators.*
   - utilize appropriate regionalization schemes (*e.g.*, ecoregions, subregions) to stratify and partition natural variability for ambient indicators.
   - incorporate tiered and refined use designations in the State WQS as appropriate.
   - use the water indicators hierarchy (Figure 3) as an operational framework for State water quality management programs - make linkages between administrative activities and indicators of stress, exposure, and response.

Water Quality-Based Decisions Which Would Benefit From Better Monitoring & Assessment Information

Water Quality Standards:
- Refined and stratified designated uses and criteria
- Biological criteria
- Site-specific applications (*e.g.*, dissolved metals translators, design temperature & pH, hardness)
- Water effect ratios
- Anitdegradation
- Ground truthing revisions to water quality criteria

TMDLs:
- Delineating impaired segments and associated causes & sources
- Wasteload allocation (model calibration & verification

NPDES Permits:
- Impact assessment
- Toxicity assessment (*i.e.*, WET testing)
- Overall permit program effectiveness

Nonpoint Sources:
- Delineating impaired segments and prioritization of watersheds
- Database for State Nonpoint Source Assessments

404/401 Dredge & Fill:
- Improved site-specific review and approval criteria
- Minimize exemptions via nationwide permits

Ground Water:
- Development of ambient background characteristics

Wetlands:
- Improved wetlands classification and delineation criteria

III. STATE MONITORING & ASSESSMENT PROGRAM OBJECTIVES

The following are some of the major objectives that State monitoring & assessment programs should have as priorities. Fully meeting some of these objectives will require time to acquire and develop the necessary database, indicators, and staff expertise. However, this will be partly dependent on the status of existing and past State monitoring and assessment efforts. Nevertheless, using the following objectives provides a basis for determining the adequacy of a given State program. A well rounded approach to indicators and monitoring design utilizing a core set of chemical, physical, and biological indicators should provide the information needed to simultaneously meet these objectives without the need to redesign the approach for each different objective.

1. Baseline characterizations of surface water resources:

   - status and trends information.
   - aquatic resource characterization.

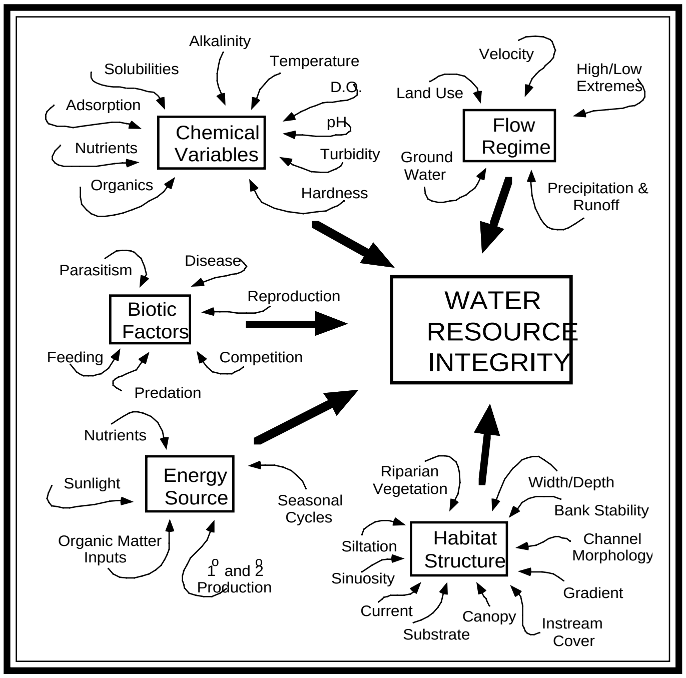

Figure 2. The five major factors which determine the integrity of the water resource (modified after Karr et al. 1986).

2. Identification and characterization of existing and emerging problems:

   - selection of indicators and the overall indicator framework will strongly influence the adequacy of problem identification and characterization (we cannot address problems that we do not know about or adequately understand).
   - the indicator framework and monitoring design must be prepared to provide information and insights to problems that may not yet be understood or even recognized.
   - there will be a need to go beyond point source paradigms.
   - make better linkages between designated uses and indicators.

3. Guide and evaluate the water quality management and regulatory process:

   - monitoring & assessment information should drive the regulatory and management processes from problem identification to assessing the effectiveness of these efforts.
   - the 305[b] process (*i.e.*, Water Body System) should be the central reporting mechanism for State programs - this will further benefit the national assessments compiled by EPA, other federal agencies, and private organizations.
   - support the development and refinement of aquatic life and other designated uses in State WQS.
   - examples of other regulatory and management programs that can be influenced include 303[d] listing, TMDLs, water quality-based permitting, compliance and enforcement, prioritizing grants and other financial assistance, the State nonpoint source assessment (319 program), etc.
   - monitoring and assessment information should provide the impetus for “new” regulatory or program management directions (*e.g.*, initiatives to restore and protect riparian habitat, nutrient criteria, sediment criteria, stream protection, antidegradation) and enhance existing efforts (CSOs, stormwater, 404/401 program, chemical criteria validation, biological criteria).

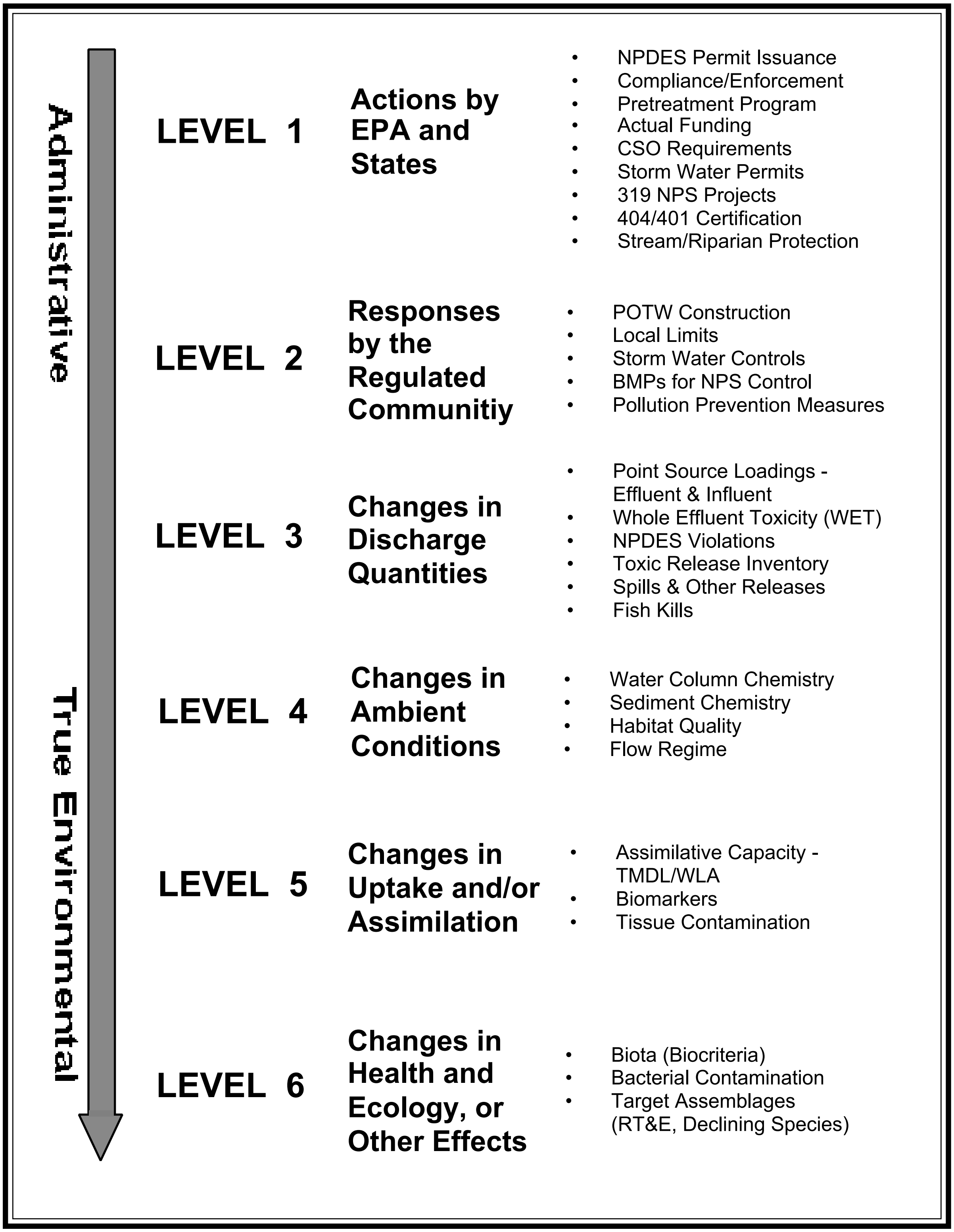

Figure 3. Hierarchy of administrative and environmental indicators which can be used by States for monitoring and assessment, reporting, and evaluating overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995b).

4. Evaluation of overall water quality management program effectiveness:

   - demonstrate the effectiveness of 25+ years of CWA program implementation.
   - establish linkages between administrative activities (*i.e.,* “bean counts”) and environmental results (*i.e.,* ambient chemical, physical, and biological indicators).
   - which actions worked and which ones did not? - provide insights on why and suggest what specific program and/or resource adjustments might be needed.

5. Responding to emergencies, complaint investigations:

   - quantify environmental damages on a spatial and/or temporal basis.
   - characterize resources at risk.
   - define the magnitude of apparent problems.

6. Identify and characterize reference conditions:

   - baseline for development of indicator benchmarks for evaluating designated use attainment/ non-attainment (*e.g.,* biological criteria) and other management objectives.
   - this functions as a long term data source for characterizing ambient biological, chemical, and physical conditions through time.

IV. MONITORING & ASSESSMENT PROGRAM DESIGN ISSUES

Monitoring and assessment program design includes the different types of indicators and the frameworks within which each is developed and used. This in turn determines the different types of data that will need to be collected and synthesized into information in order to successfully realize the previously stated goals and objectives. Spatial considerations about the basic design of the monitoring program are also included and will be most influenced by the overall program goals and objectives of each State. State monitoring and assessment programs serve multiple needs and must function across multiple scales (*i.e.,* local watershed, basin/subbasin, statewide), thus consideration of more than one approach will likely be needed.

Environmental Indicators for Surface Waters

1. The most appropriate roles of indicators are defined as follows:

   - Stressor Indicator - measures of activities which have the potential to impact the environment (*e.g.,* pollutant loadings, land use characteristics, habitat changes).
   - Exposure Indicator - measures of change in environmental variables which suggest a degree (magnitude and duration) of exposure to a stressor (*e.g.,* chemical pollutant levels in water and sediment, toxicity response levels, habitat quality indices, biomarkers).
   - Response Indicator - usually a composite measure or other expression of an integrated or cumulative response to exposure and stress (*e.g.,* biological community indices, status of a target species, etc.).
   - The problem nationally with inconsistent 305[b] statistics (and by extension inconsistent 303[d] and 304[l] lists, etc.) is usually the result of the inappropriate substitution of stressor and/or exposure indicators in the place of response indicators - this is commonly due to the lack of

information about response indicators.

- The exclusion of response indicators and the inappropriate substitution with exposure and/or stressor indicators ultimately influences what States report in terms of waters meeting designated uses. An example of this is illustrated in Figure 4 where some State estimates of aquatic life use attainment based on surrogate approaches are much different than estimates based primarily on biological assessments (U.S. EPA 1996).

2. Use the EPA hierarchy of indicators (U.S. EPA 1995b; Figure 3) as a template to improve the integration of administrative actions and measures with environmental indicators within the State water quality management process:

   - The EPA hierarchy of surface water indicators links traditional administrative approaches (permitting, funding, compliance, enforcement) with environmental indicators which simultaneously sequences stressor, exposure and response indicators - six levels (Figure 3).
   - The six level hierarchy can become an operational template for implementing environmental indicators and monitoring information within a State water quality management process via a watershed approach. This will facilitate the development of case histories about what works and what does not, showing where information gaps exist, and providing opportunities for feedback throughout the process. An example from the Ohio pilot water indicators demonstration project is included in the selected examples (Part IX.).

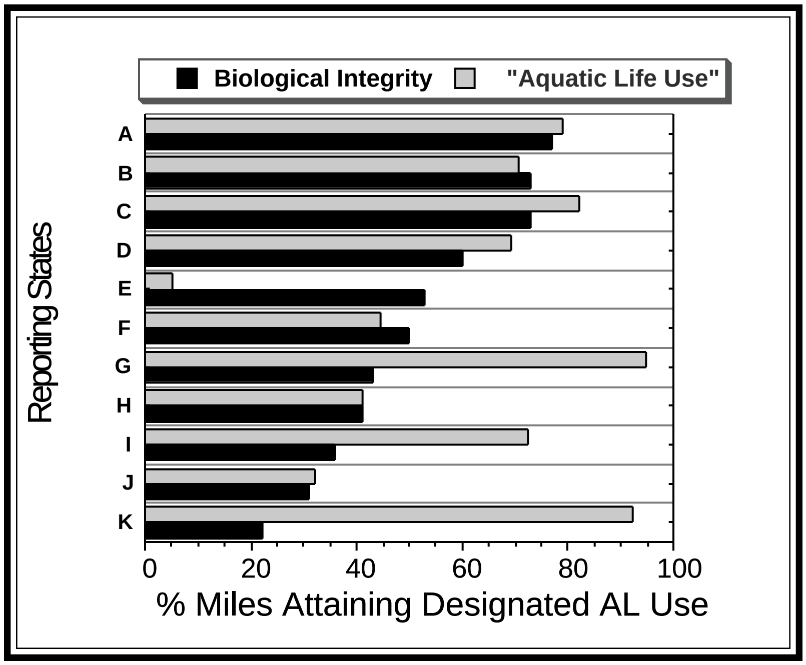

Figure 4. Miles of rivers and streams reported as fully supporting designated aquatic life uses based on varying methods used by 11 states in their 305[b] reports (light shading) compared to that based on biological assessments (after U.S. EPA 1996).

Monitoring Design Approaches

A key issue facing the States and EPA is selection of an appropriate monitoring design. It has been recognized for some time that the traditional fixed station design (*e.g.*, NAWQMN, NASQAN) common to many State monitoring networks is alone insufficient to meet the above stated objectives. However, State monitoring and assessment resources even under the best of circumstances have been limited and therefore must be prioritized. Thus, selection of the most cost and information effective spatial design is a critical step in the process. Two approaches, a synoptic, targeted design commonly referred to as a rotating basin approach and the probabilistic design developed by the U.S. EPA EMAP program are summarized here. The strengths and weaknesses of each are indicated with respect to the multiple issues that State monitoring and assessment programs must address. A case example from the Ohio portion of the E. Corn Belt Plains ecoregion Regional EMAP project is included in Part IX.

Rotating Basin Approach

1. Strengths:
   - organized, systematic approach based on accumulating assessment information at a local scale over a fixed period of time, usually 5 or 10 years.
   - coincides with various management programs which are supported by the monitoring & assessment information (*i.e.,* NPDES permit reissuance, basin-wide water quality planning, proposed 5-year 305b reporting cycle).
   - provides monitoring & assessment information at a local or reach specific scale so that the many issues which occur at this level can be addressed while providing the opportunity to aggregate upwards to a watershed, regional, statewide, or national scale once sufficient data exists.
   - there is more opportunity to define gradients of specific human disturbances with assessment information (*e.g.,* Karr's human activity "dose" - ecological response curve).
   - develop and maintain tabs on reference condition in a predictable and standardized time frame.

2. Weaknesses:
   - visiting a basin/segment/watershed only once in 5 or 10 years may not be sufficient to satisfy all needs.
   - larger scale assessment information (*i.e.,* in support of a valid statewide assessment) is generally not available for 5-10 years.

Probabilistic Design

1. Strengths:
   - statistically robust design.
   - "faster" route to a statewide assessment - aggregate to national scale.
   - transcends State boundary limitations - can facilitate collaborative monitoring between States.

2. Weaknesses:
   - lacks site-specific/issue-specific resolution.
   - logistics are potentially more difficult (*i.e.,* more difficult access to remote monitoring sites).
   - reference condition may be more difficult to define on probability basis alone.
   - local scale issues may be overlooked.

V. AQUATIC RESOURCE CHARACTERIZATION

Defining the different aquatic resource types that a State program must address is a critical step in the process. This includes the major aquatic ecosystem types such as flowing waters (*i.e.,* rivers and streams), lakes and reservoirs, coastal waters, great lakes, estuaries, or wetlands. Further stratification within each is possible (*e.g.,* headwater streams, wadable streams, large rivers, depressional wetlands, riparian wetlands, etc.) and may be accounted for *a priori* or as part of the indicator development and calibration process. Other stratification elements, which includes watershed driving factors (*e.g.,* ecoregions) and other physical vectors, are incorporated as well. Designated aquatic life uses provide an additional layer of stratification. Taken together all of these processes should result in more finely tuned indicator expectations or benchmarks against which management program success will ultimately be judged.

VI. STATE MONITORING & ASSESSMENT COMPONENTS AND RESOURCES

State monitoring and assessment programs need to include the appropriate ambient measurements in order to adequately meet the previously stated goals and objectives. The Intergovernmental Task Force on Monitoring Water Quality (ITFM 1995) recommended the minimum elements of an adequate monitoring and assessment program that will support meeting the previously stated goals and objectives (Table 1). This also represents the elements essential to implementing the hierarchy of water indicators framework (Figure 3) which, in turn, is needed to not only demonstrate program effectiveness, but provide opportunities for feedback resulting in future program improvements.

The ITFM (1995) concluded that the implementation of the ITFM recommendations and strategy would result in an adequate information base to achieve the environmental protection and natural resource management goals and objectives established for the nation's aquatic resources. However, it was also recognized that full implementation of the strategy could not be achieved "overnight" and that the necessary capacity and resources (*i.e.,* the monitoring and assessment "infrastructure") will need to be acquired over a reasonable period of time. Nevertheless, monitoring organizations, including States, will need to review, update, and/or revise their monitoring strategies in a series of deliberate steps. The demands that are increasingly being placed on our water resources at all scales require that past approaches to monitoring be significantly improved both in terms of quality and quantity. Some of the steps towards a more comprehensive and effective approach to ambient monitoring include the following which also summarizes the major points of this document:

1. Develop a goal oriented approach to monitoring, assessment, and indicators development where indicators are sufficiently specific so as to explicitly measure the identified national goals and those relevant to State WQS.

2. Evaluate information priorities and identify existing information gaps.

3. Develop a comprehensive and flexible approach that addresses all relevant scales and aquatic resource types.

4. Take advantage of inter-organizational collaboration whenever appropriate.

5. Link traditional compliance monitoring with watershed-based ambient monitoring.

6. Deal effectively with methods comparability to maximize the flexibility in monitoring and assessment approaches while producing data and information of known quality and power of assessment.

7. Automate and streamline data and information management including data entry, storage, and retrieval.

8. Develop better assessment and reporting at all relevant scales; publish results on a regular basis.

9. Promote the development of incentives and the elimination of disincentives to the development of better State ambient monitoring programs and indicators.

Table 1. Summary matrix of recommended environmental indicators for meeting management objectives for status and trends of surface waters (shaded boxes with ***X*** *are recommended as a primary indicator after ITFM 1995; other recommended indicators are indicated by* **✓). ** *The corresponding EPA indicator hierarchy level is also listed between indicator groups.*

	Categories of Management Objectives					
	Human Health		Ecological Health		Economic Concerns	
Indicator Group	Consumption of Fish /Shellfish	Public Water Supply	Recreation (swimming, fishing, boating)	Aquatic/ Semi-aquatic Life	Industry/ Energy/ Transportation	Agriculture/ Forestry
Biological Response Indicator (Level 6)						
Macroinvertebrates		X	X	X		X
Fish	X		X	X		X
Semiaquatic Animals	X		X	X		X
Pathogens	X		X			X
Phytoplankton	X	X	X	X	X	
Periphyton				X		
Aquatic Plants		X	X	X	X	X
Zooplankton		X	X	X		X
Chemical Exposure Indicator (Level 4&5)						
Water chemistry	X	X	X	X	X	X
Odor/Taste	X	X	X			
Sediment Chemistry	X	X	X	X	X	X
Tissue Chemistry	X	X	✓	X	X	
Biochemical Markers	✓	✓	✓	✓		✓
Physical Habitat/Hydrologic Indicator (Levels 3&4)						
Hydrological Measures	X	X	X	X	X	X
Temperature	X	X	X	X	X	✓
Geomorphology	X	X	X	X	X	X
Riparian/shoreline	X	X	✓	X	X	X
Ambient Habitat Quality	✓	✓	✓	✓	✓	✓
Watershed Scale Stressor Indicators (Levels 3,4&5)						
Land Use Patterns	X	X	X	X	X	X
Human Alterations	X	X	X	X	X	✓
Watershed Impermeability	✓	✓	✓	✓	✓	✓
Pollutant Loadings Stressors (Level 3)						
Point Source Loadings	✓	✓	✓	✓	✓	✓
Nonpoint Source Loadings	✓	✓	✓	✓	✓	✓
Spills/Other Releases	✓	✓	✓	✓	✓	✓

Simply upgrading the monitoring program to include more and better measurements and the better conversion of data to information, while important, is alone insufficient. To achieve the overall goal of improving the use of monitoring and assessment information in the emerging watershed approach, water quality management must mature to focus primarily on the condition of the environment as the overall measure of program success (Figure 5). Whereas the performance of the "program" was

Two Approaches to Watershed-Based Water Quality Management

	PROGRAM FOCUSED APPROACH	RESOURCE FOCUSED APPROACH
Goal:	Program Performance	Environmental Performance
Measures:	Administrative Actions	Indicator End-points
Results:	Improve Programs	Programs are Tools to Improve the Environment

Figure 5. The goals, measures, and results of program based and resource based approaches to water quality management. State programs will evolve towards a resource based approach by developing and using a sufficiently comprehensive and rigorous system of environmental indicators.

once the principal measure of effectiveness, the program must be viewed as a tool to be used along-side monitoring and assessment and environmental indicators to improve the quality of the environment.

VIII. REFERENCES

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IX. INDICATORS & PARAMETERS FOR ADEQUATE STATE MONITORING & ASSESSMENT PROGRAMS

The following supplemental figure shows core and supplemental indicators and parameters that are used in an adequate State monitoring and assessment program. This is patterned after the recommendations of the Intergovermental Task Force on Monitoring Water Quality (ITFM 1995). The core indicators are measured everywhere and are supplemented by a variety of chemical and physical measurments depending on the applicable designated use(s) and watershed-specific needs.

CORE INDICATORS/PARAMETERS

• Fish Assemblage • Macroinvertebrates • Periphyton
(Use Community Level Data From At Least Two)

Physical Habitat Indicators
- Channel morphology
- Flow
- Substrate Quality
- Riparian

Chemical Quality Indicators
- pH
- Temperature
- Conductivity
- Dissolved O_2

For Specific Designated Uses Add the Following Parameters:

AQUATIC LIFE
Base List
- Ionic strength
- Nutrients, sediment

Supplemental List
- Metals (water/sediment)
- Organics (water/sediment)

RECREATIONAL
Base List
- Fecal bacteria
- Ionic strength

Supplemental List
- Other pathogens
- Organics (water/sediment)

WATER SUPPLY
Base List
- Fecal bacteria
- Ionic strength
- Nutrients, sediment

Supplemental List
- Metals (water/sediment)
- Organics (water/sediment)
- Other pathogens

HUMAN/WILDLIFE CONSUMPTION
Base List:
- Metals (in tissues)
- Organics (in tissues)

Supplemental Figure 1. Core indicators and parameters for an adequate State watershed monitoring and assessment program with supplemental chemical parameters according to the applicable designated use(s). Parameters are added based on site and watershed-specific needs and overall water quality management objectives.

X. CASE EXAMPLES
(ASIWPCA Meeting Version)

Case examples of how monitoring and assessment information based on an integrated water indicators framework can be used to address some of the key goals and objectives of this guidance document are appended. These examples provide tangible evidence of how good monitoring and assessment information can be used to not only support specific program areas, but the overall water quality management process in general.

A. Pennsylvania DEP
The Pennsylvania examples show how the DEP is responding to the settlement of a TMDL suit by committing to increased monitoring and assessment (biological monitoring in particular) statewide.

B. Tennessee Valley Authority (TVA)
The TVA has traditionally been a leader in using ambient monitoring information to meet their water quality management obligations. The examples appended here portray the types of monitoring and assessment, the spatial design, and how this has fostered a better approach to inter-organizational collaboration.

C. Wisconsin DNR
A published paper from the Wisconsin DNR shows how biological and habitat information was used to determine the effects of nonpoint sources and land use on the integrity of Wisconsin streams. This should begin to point out how this type of information can be used in the TMDL process.

D. Ohio EPA
A number of examples from the Ohio EPA surface water monitoring and assessment program are presented and include:

- fact sheets from the 1996 Ohio Water Resource Inventory (305b report);
- watershed profiles from two basin survey areas.
- preliminary results from the E. Corn Belt Plains Ecoregion REMAP project;
- a synopsis of figures from the pilot water indicators project; and,
- three examples of how ambient monitoring data can be used to validate and/or derive chemical water quality criteria.

E. U.S. EPA, Office of Water
The most recent version of the U.S. EPA Section 106 monitoring guidance attempts to foster helping States to achieve the many goals and objectives stated herein.

XI. OHIO EPA CASE EXAMPLES:

I. 1996 Ohio Water Resource Inventory (305[b] Report) Fact Sheets:

- Streams and Rivers Status
- Causes and Sources of Impairment
- Streams and Rivers: Siltation & Habitat Destruction
- Impaired Waters in Ohio: What Does This Mean?

II. An Evaluation of Spatial Monitoring & Assessment Design: Preliminary Results from the E. Corn Belt Plains REMAP Project

III. Ammonia Fact Sheets
- Associations Between the Index of Biotic Integrity and Unionized Ammonia in Ohio Rivers and Streams: A Preliminary Analysis
- Associations Between the Index of Biotic Integrity and Total Ammonia in Ohio Rivers and Streams: A Preliminary Analysis

IV. Ohio EPA Pilot Indicators Project figures

V. Watershed Profile Summaries
- Sandy Creek
- Little Miami River